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SIDE-SCAN SONAR ESTIMATION OF SALMON ESCAPEMENTS INTO TOGIAK RIVER, TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA

Progress Report

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SIDE-SCAN SONAR ESTIMATION OF SALMON ESCAPEMENTS INTO TOGIAK RIVER, TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA

Progress Report

James E. Finn

Key Words: side-scan, sonar, salmon, chinook, chum, coho, pink, sockeye, escapement, estimate, Togiak River, Togiak National Wildlife Refuge, Alaska.

U.S. Fish and Wildlife Service
King Salmon Fishery Assistance Office
P.O. Box 277
King Salmon, Alaska 99613

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ABSTRACT

A three year study was initiated in 1987 to test the feasibility of using side-scan sonar to estimate salmon escapements into the Togiak River, Alaska. Side-scan sonar adult salmon counters were operated from 12 August - 22 September near river kilometer 30 with the transducers mounted on portable tripods. The river channel was about 110 m wide at the counting site, and maximum sonar counting ranges were 61.0 m from the east bank and 30.5 m from the west bank.

The total seasonal salmon count was 137,497. Visual counts, beach seine and gill net catches were used to estimate species composition. Coho salmon escapements were estimated at 68,428. This estimate is suspect as: (1) fish passage was still occurring when counting was terminated; (2) fish milling behavior and slow swimming speeds in the east portion of the river caused over counting that could not be totally adjusted for; (3) species composition estimates were often based on data pooled over ten or more days; (4) species composition estimates were primarily based on catches from one side (east) of the river; and (5) gear selectivity may have biased species composition estimates.

An alternative site was tested and results indicated that fish milling behavior and slow swimming speeds can be avoided at this site during periods of low river flows. The emphases for 1988 will be: (1) an increased operational period (mid June - September) to test the feasibility of estimating chinook, coho, chum, sockeye and pink salmon; (2) modification of sonar counters to adjust for slower swimming speeds; (3) refinement of fish capture techniques to increase daily sample sizes for species composition; (4) increased visual observation to validate sonar counts; and (5) establishment of alternative counting sites. The 1987 results indicate that side-scan sonar has potential for estimating salmon escapements into Togiak River on an in-season basis.

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INTRODUCTION

The Togiak River supports runs of sockeye (Oncorhynchus nerka), chinook (O. tshawytscha), coho (O. kisutch), chum (O. keta) and pink (O. gorbuscha) salmon. In 1986 the Togiak commercial fishing district contributed about 26 percent of the coho, 22 percent of the chinook and 24 percent of the chum salmon commercially harvested in Bristol Bay (Alaska Department of Fish and Game 1987). In comparison, the Togiak district sockeye salmon harvest accounted for less than one percent of the total 1986 Bristol Bay sockeye harvest. However, with an average (1982-1986) escapement of 209,000 fish (Alaska Department of Fish and Game 1987), the Togiak River sockeye salmon run is an important fishery resource of the Togiak National Wildlife Refuge (Refuge) and for commercial and subsistence fishermen.

Present Togiak River escapement goals established by the Alaska Department of Fish and Game (Department) are: 10,000 chinook; 150,000 sockeye; and 50,000 coho salmon. The chum salmon escapement goal of 200,000 fish is for the entire Togiak commercial fishery district and not specific for the Togiak River. No escapement goal has been set for pink salmon as they are harvested incidentally but not targeted in the commercial fishery.

Tower counts, aerial surveys and commercial catch data are used by the Department to manage for Togiak River salmon escapement goals. Sockeye salmon escapement estimates are based on counts taken at the Department tower at river km (Rkm) 97 (measured from Togiak Bay to Togiak Lake). Fish enumerated at

the tower have escaped the commercial fishery about 10 to 14 days earlier (Brannian 1982), and two commercial fishing periods can occur before fish reach the tower. With strong runs escapement goals can be easily met. However, if runs are weak it becomes difficult to monitor the status of the escapement on an in-season basis.

Aerial surveys are often curtailed due to weather and turbid water conditions. This can result in unequal aerial survey coverage over a season and between years. Also, aerial surveys only provide instantaneous, rather than total, escapement estimates.

The relationship between commercial fishing catch-per-unit-effort and sockeye escapement has been modeled and is a relatively good estimator of sockeye salmon escapements if commercial fishing is maintained at a fixed number of openings-per-week (Brannian 1982). This requirement (fixed number of openings-per-week) may not be possible during years when runs are weak or if fishing pressure increases, hence, this model is limited by a lack of flexibility.

Side-scan sonar can generate daily escapement estimates (and unlike tower counts, aerial surveys and catch-per-unit-effort models) sonar enumeration is not dependent on water clarity, weather conditions or consistent commercial fishing effort. The present sonar systems are unable to distinguish between fish species, and it is necessary to sample migrating fishes, either visually or with nets, in order to apportion sonar counts between species.

To improve the Togiak River salmon escapement data base the King Salmon Fishery Assistance Office, in cooperation with the Department and the Togiak Refuge, is testing the feasibility of using side-scan sonar to enumerate salmon, by species, on Togiak River. Sonar enumeration has the potential to: (1) estimate the escapements of chinook, chum, coho, sockeye and pink salmon on an in-season basis independent of run strength and commercial fishing activities; and (2) reduce the time lag by five to seven days between sockeye salmon escapement from the commercial fishery and enumeration. The focus of the first season (1987) was experimentation with site selection, sonar equipment and fish collection techniques.

STUDY AREA

The Togiak River is located in southwestern Alaska with approximately 70 percent of the river drainage within the Togiak National Wildlife Refuge Wilderness Area (Figure 1). The climate is influenced by the maritime regime of Bristol and Kuskokwim Bays and the continental regime of interior Alaska. Average minimum and maximum air temperatures are about -16°C and 16°C, respectively. Average annual precipitation is about 63 cm and snowfall ranges from 152 to 172 cm along the coast to greater than 381 cm in the mountains (U.S. Fish and Wildlife Service 1985).

Togiak River originates at Togiak Lake (3,884 hectares) and flows about 97 km to the south before draining into Togiak Bay.

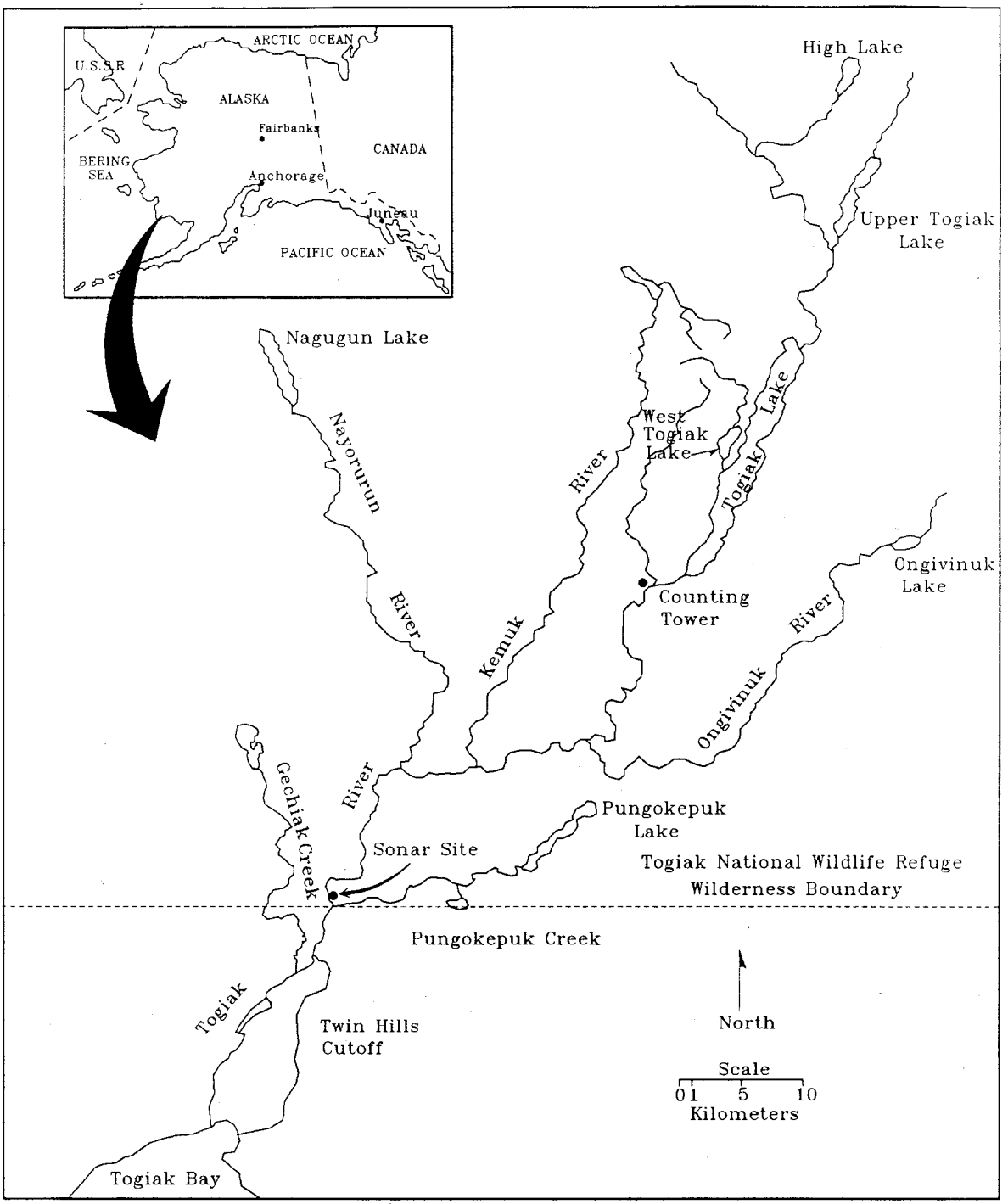

Figure 1.-Approximate location of side-scan sonar facilities, Alaska Department of Fish and Game counting tower and major tributaries of Togiak River, Alaska.

The Togiak River drainage (5,178 km^2) is a complex system with five major tributaries (Gechiak Creek, Pungokepuk Creek, Nayorurun River, Kemuk River and Ongivinuk River) and nine major lakes (Figure 1). At Rkm 21 a channel of the river diverges from the main stem to form the Twin Hills Cutoff. The Cutoff parallels the Togiak River and drains into Togiak Bay 1.6 km to the east. Above Rkm 21, the river is primarily confined to one channel. Below Rkm 21, the river is often braided into multiple channels.

METHODS

Site selection and establishment of the sonar camp occurred from 15 July-15 August 1987. Operation of both sonar counters and fish sampling occurred from 12 August-22 September 1987.

Site Selection

River characteristics required for sonar operation include: (1) single channel (multiple channels require additional sonar units); (2) relatively constant river bottom slope from both banks to the deepest channel; (3) moderate sized substrate; (4) moderately uniform flow rate; and (5) the site should not be located in salmon spawning areas and should be as close to the river mouth as possible (King 1984).

Visual observations of bank type, substrate type and channel configuration were made from the mouth of the river upstream to about Rkm 50. Multiple channels and islands excluded much of the river from consideration. River bottom profiles (determined by a

Lowrance[1] Eagle Mach I chart recording echo sounder) further reduced the number of areas for site consideration. Potential sites were located near Rkm 30, Rkm 36 and Rkm 40. The site near Rkm 30 was chosen for sonar operations during 1987, as it most closely met the site selection criteria. An east bank alternate site, approximately 300 m downstream, was tested from 9-11 September.

Side Scan Sonar

Bendix Corporation side-scan sonar adult salmon counter systems were set up on both sides of the river with the transducers offset by approximately 50 m (Figures 2 and 3). Hardware components of the sonar system included: counter; transducer; oscilloscope; and power supply (12 V battery and solar panel). Sonar theory, equipment setup, operation and calibration are detailed in Gaudet (1984) and Tarbox et al. (1983).

The transducers were mounted on portable tripods which allowed for precise aiming of the sonar beam. A weir of steel fence posts was positioned downstream of each tripod to prevent fish from passing behind the transducers.

Sonar counters were calibrated (comparing valid targets on the oscilloscope with counts registered by the sonar counter) every two to four hours with a minimum target goal of 50

[1]Trade names are for reader information only and do not constitute endorsement by the U.S. Government of any commercial product or service.

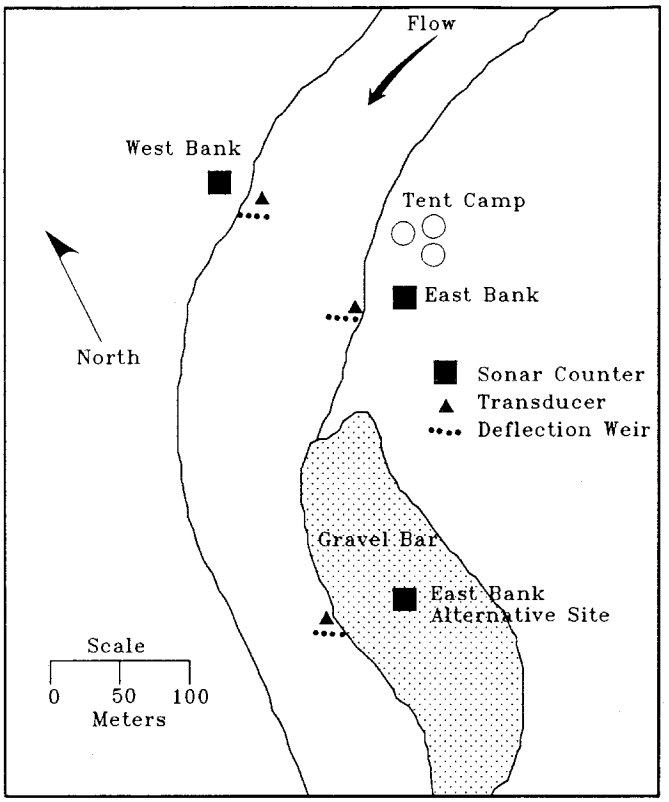

Figure 2.-Side-scan sonar facilities, Togiak River, Alaska, 1987.

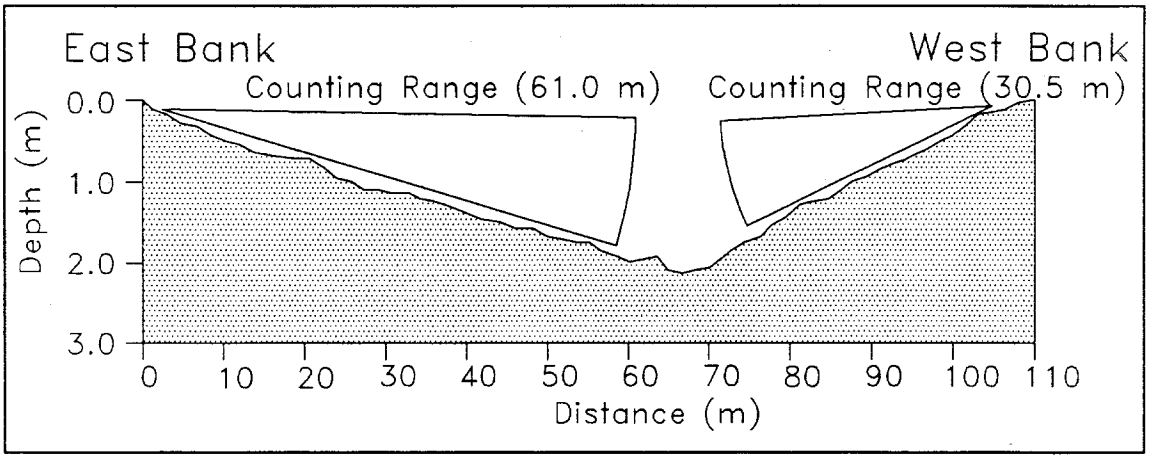

Figure 3.-River channel profile and side-scan sonar counting ranges (the west bank transducer was 50m upstream from the east bank transducer), Togiak River, Alaska, 1987.

oscilloscope counts per calibration. Ping rates (rate at which signals are pulsed) were adjusted when deviations were greater than 20 percent (i.e., when $Q < 0.8$ or $Q > 1.2$, where Q = sonar count/oscilloscope count) using the following formula:

$$\text{New Ping Rate} = Q \times \text{Current Ping Rate}$$

Visual observations were made from the bank and 2 m high platforms. Visual observations of passing fish were used to check oscilloscope calibrations when lighting and water clarity allowed.

Water Velocity Measurements

Water velocity was taken at the sonar sites using a Marsh-McBirney flow meter and top setting wading rod. Mean water velocity was measured at 0.6 of the water depth up to water depths of 0.75 m, and at water depths greater than 0.75 m, mean water velocity was the average of the velocities measured at 0.2 and 0.8 of the water depth. Water velocity was also measured just above the substrate (approximately 2.0 cm above the substrate).

Adjustment and Estimation of Daily Counts

The sonar counting ranges were subdivided into 12 equal sectors (a factory preset feature), and the counts per sector were printed each hour. Hourly sector counts (n = 12 sectors x 24 hours = 288) were transferred daily to a summary sheet for initial daily count estimates. When hourly sector counts (blocks) were missed due to false counts caused by debris and

passing boats or periods when the transducers were moved, daily counts were adjusted in the following manner:

$$\text{Adjusted Daily Count} = \frac{\text{Daily Count} \times 288}{(288 - \text{Number of Missing Blocks})}$$

Fish movement along the east shore was too slow to allow for acceptable calibration through ping rate adjustments, i.e., the slowest ping rate still resulted in over counting exceeding 20 percent. Therefore, east bank daily counts were adjusted by dividing the daily count by the daily Q value (sum of daily sonar counts/sum of daily oscilloscope counts).

Due to equipment failure, low water levels and experimentation at the alternate east bank site, daily counts were either missed or were erroneous 10 times on the west bank and once on the east bank. These 11 daily counts were estimated by averaging the four most recent daily counts (two before and two after). Estimated daily counts were then used to calculate subsequent missing daily counts.

Fish Collection

A 45 m by 2.4 m beach seine of 7.6 cm stretch mesh and a 15 m by 2.4 m gill net of 14 cm stretch mesh were used to collect species composition, length and scale samples. Beach seine sites were established on both banks about 50 m downstream from the transducers. Daytime beach seining and drift gillnetting were conducted during 12-21 August. After 23 August all sampling was done with gill nets during darkness (2200-0700 hours).

All fish were identified to species and counted. Coho salmon were sexed (using external morphological characteristics), measured to the nearest mm (mid-eye to caudal fork) and a scale was taken from the preferred scale area (Jearld 1983). Scales were mounted between microscope slides and magnified 20 to 60 times for ageing. Age designations followed the Gilbert-Rich formula where 3_2 designates a fish which smolted during its' second year and returned to spawn during its' third year (Koo 1962).

Species Composition

Species composition of sonar counts was based on beach seine and gill net catches and visual counts. Submerged boulders along the west bank precluded gillnetting in the western half of the river. Therefore, species composition estimates applied to the west bank counts were based on east bank data. The sample size used for species composition estimates was based on guidelines developed for age composition estimation (Bernard 1983). Estimates of species composition where the number of species = 3, alpha = 0.1 and precision ($SE/\bar{X}$) = 0.1 require a minimum sample size of 120.

Visual and catch data were used to estimate species composition from 12-24 August. Visual counts were used to estimate the percentage of bright fish (fish which had not developed spawning colors), dark sockeye salmon (fish in spawning colors) and chum salmon passing the sonar. Bright fish were assumed to be either fresh sockeye or coho salmon. No bright

chinook or chum salmon were observed in any catches, and all coho captured during 12-24 August were bright. Beach seine and gill net catches were used to estimate the percentages of coho and sockeye in the visually counted bright fish. The numbers of chum, sockeye (estimated number of bright sockeye plus visually counted dark sockeye) and estimated coho salmon per the total visually counted sample were then used for species composition estimates.

After 24 August visual counts were minimal and species composition was based on catch data. A moving five day average of species composition estimates was used for final escapement estimates. Chinook salmon and pink salmon catches were not used for species composition estimates.

Results and Discussion

Calibration

Daily sonar counts were obtained for 41 days on the east bank and 28 days on the west bank. Through ping rate adjustment, the deviation between sonar counts and oscilloscope counts was maintained within an acceptable range (i.e., $0.8 \leq Q \leq 1.2$) for the west bank 61 percent of the time ($\bar{X} = 0.97$, SE = 0.05). The Q values for the east bank exceeded acceptable levels on all days ($\bar{X} = 2.14$, SE = 0.10) (Figure 4). Visual counts combined with oscilloscope counts were only possible from the east bank for one week, but oscilloscope counts correlated strongly with actual fish passage ($r = 0.99$, $P < 0.01$) (Table 1).

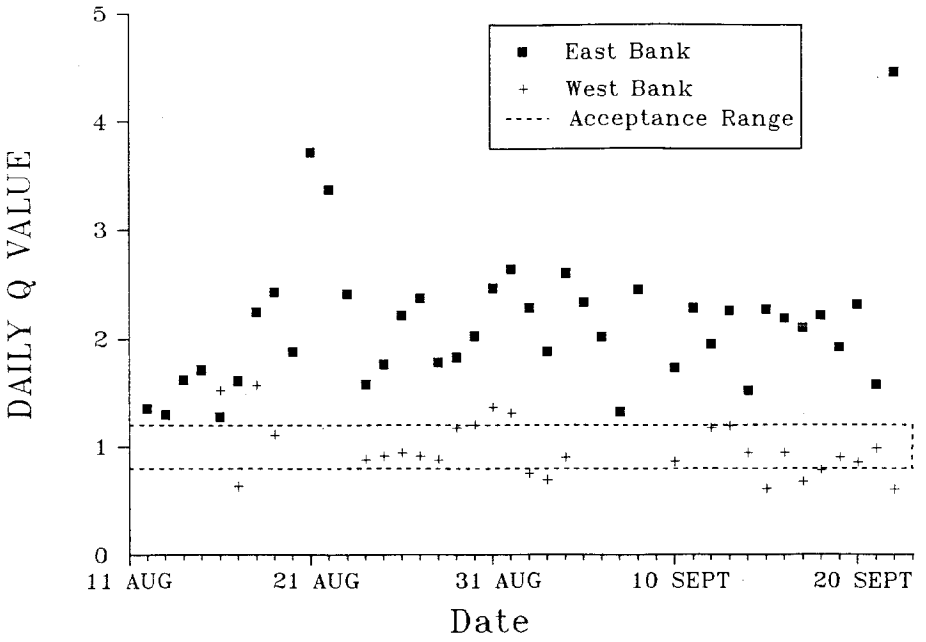

Figure 4.-Daily Q values and acceptance range for east and west bank side-scan sonar, Togiak River, Alaska, 1987.

Table 1.-Oscilloscope and visual counts of salmon passing the east bank sonar site, Togiak River, Alaska, 1987.

Date	Oscilloscope Count	Visual Count	Oscilloscope Count/ Visual Count
14 August	24	23	1.04
15 August	31	33	0.94
17 August	162	148	1.10
18 August	173	184	0.94
20 August	15	15	1.00
21 August	7	7	1.00
Total	412	410	1.01

The lower water velocities and shallow depths along the east bank may have induced fish milling behavior and slow swimming speeds. At the east bank alternate site, faster nearshore water velocities (Table 2) apparently eliminated the milling behavior and slow swimming speeds prevalent at the original east bank site. During 9-10 September, daily Q values decreased to an acceptable range at the alternate site (0.86 - 0.92), whereas Q averaged 1.73 and 2.28 at the original site.

It was not possible to establish a west bank site (due to a lack of platform material) near the east bank alternate site during 1987. Since the east bank alternate and west bank sites were 300 m apart, there was a high probability of fish crossing over between banks and being counted twice. Therefore, the east bank sonar was returned to the original site.

Species Composition

A total of 650 salmon were visually counted during 16-24 August (Appendix A). During 12 August-21 September 424 salmon were collected by beach seine and gill net, of which 282 were coho (Appendix B). From 12-24 August 91 salmon were collected in 41 beach seine sets. During 17-24 August 29 salmon were collected in 38 daytime gill net drifts. Night gill net drifts were done after 24 August and resulted in increased catches: 61 salmon in 28 drifts (25-27 August). All chinook salmon were post spawners and pink salmon catches were minimal. Eighty-nine char (Salvelinus sp.), one rainbow trout (O. mykiss) and one round

Table 2.-Water velocity measured at the east bank and east bank alternate sonar sites, Togiak River, Alaska, 10 September 1987.

	East Bank			East Bank Alternate Site		
		Water Velocity (m/s)			Water Velocity (m/s)	
Distance From Bank (m)	Depth (m)	Above Substrate	Mean	Depth (m)	Above Substrate	Mean
6.0	0.27	0.18	0.27	--	--	--
7.6	--	--	--	0.40	0.24	0.46
9.0	0.34	0.21	0.34	0.52	0.24	0.58
12.0	0.46	0.34	0.46	0.67	0.43	0.76
15.0	--	--	--	0.85	0.40	0.73
18.0	0.73	0.40	0.55	1.00	0.37	0.96
24.0	0.94	0.31	0.70			
27.0	1.04	0.49	0.76			

white fish (Prosopium cylindraceum) were collected incidentally but were not used in species composition estimates.

Chum salmon dominated the species composition samples when operations began in mid-August (Figure 5). By 25 August, coho salmon outnumbered chum salmon, and during September catches were almost exclusively coho salmon. Sockeye salmon generally comprised less than 10 percent of the daily samples.

The gill net mesh size may have also introduced bias into composition estimates; char which may have been counted by the sonar would not have been captured in proportion to their abundance by the gill net. However, Department aerial surveys indicated that the migration of char into the river was minimal during 1987 (W. Bucher, Alaska Department of Fish and Game, personal communication).

Escapement Estimates

A total of 137,497 fish were counted during 1987, including 85,883 from the east bank and 51,614 from the west bank (Figure 6 and Appendix C). Daily counts generally decreased during the season.

An escapement estimate was only possible for coho salmon, because counting commenced after the peak migrations of chinook, chum and sockeye salmon. Coho escapements were estimated at 38,432 for the east bank and 29,996 for the west bank, for a total estimate of 68,428 fish (Appendix D). These estimates are suspect as: (1) fish passage was still occurring when counting was terminated (Figure 7); (2) fish milling behavior and slow

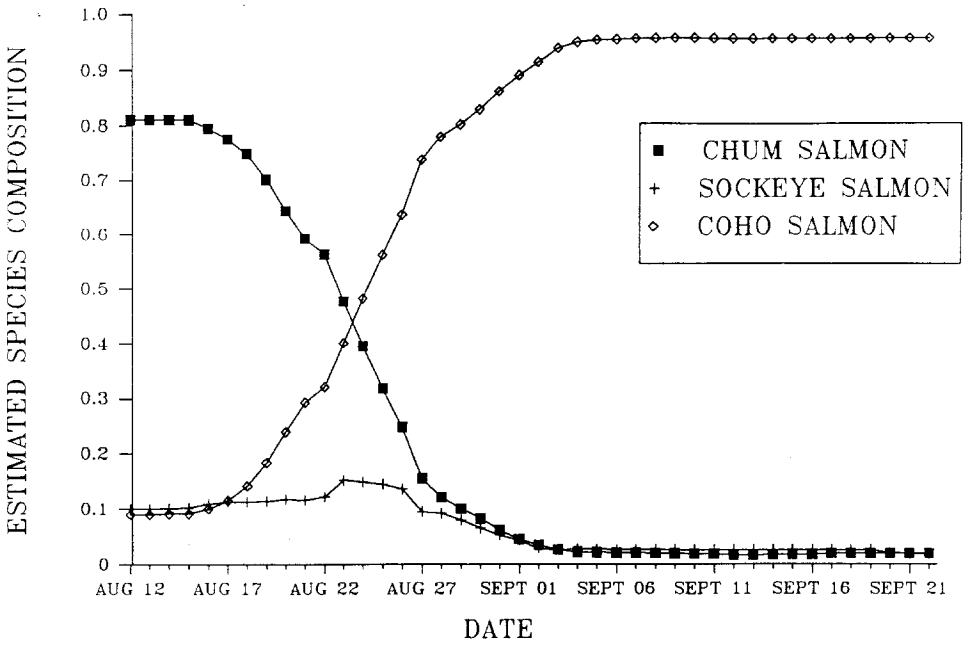

Figure 5.-Estimated species composition of chum, sockeye and coho salmon passing the side-scan sonar site, Togiak River, Alaska, 1987.

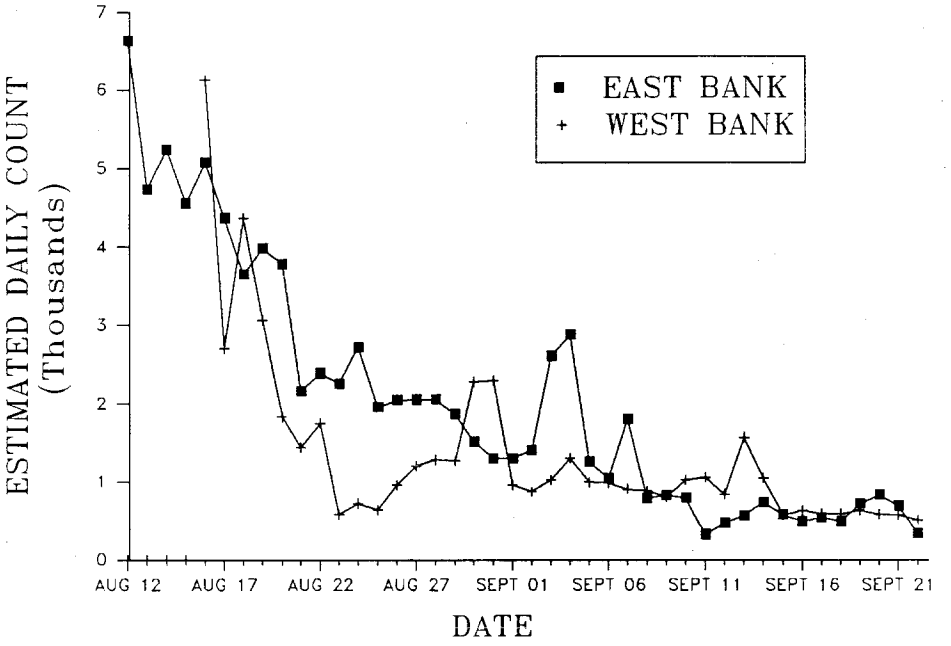

Figure 6.-Adjusted daily side-scan sonar fish counts, east bank and west bank, Togiak River, Alaska, 1987.

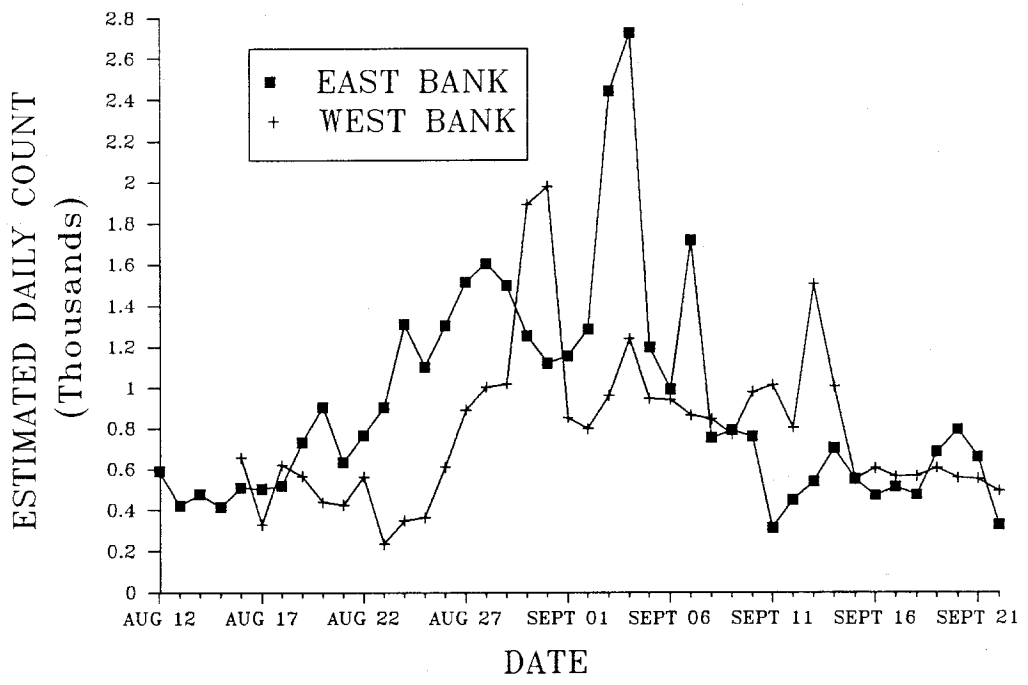

Figure 7.-Estimated daily sonar counts of coho salmon from east and west banks, Togiak River, Alaska, 1987.

swimming speeds in the east portion of the river caused over counting that could not be totally adjusted; (3) species composition estimates were often based on data pooled over 10 or more days; (4) species composition estimates were primarily based on catches from one side (east) of the river; and (5) gear selectivity may have biased species composition estimates.

Coho Salmon Count Distribution

As counting range changed over the season (Table 3), the east bank sector counts were segregated into two time periods to assess the horizontal count distribution (12-20 August, 30.5 m range and 23 August-18 September, 61 m range). During the latter time period coho counts shifted offshore (Figures 8 and 9). When the west bank counts are divided into similar time periods, a similar shift is seen (Figure 10).

Counting gaps may have occurred in west bank sectors nine and ten (16-21 August) and in sectors four and five (22 August-22 September), perhaps due to fish passage below the sonar beam in these sectors (Figure 10). Fish passage during daylight hours was too low to visually assess this phenomenon. The diurnal distribution of counts indicated a strong trend for movement during hours of darkness, 2300 to 0700 hours (Figure 11).

Coho Salmon Age, Length and Sex

Scales were collected from 268 coho salmon, but 42 percent of the scales were either unreadable or regenerated. Three-fourths of the 154 fish were age 4_3 (Table 4). Sex was

Table 3.-Sonar counting ranges for east and west banks, Togiak River, Alaska, 1987.

Date	Bank	Counting Range (m)
12-20 August	East	30.5
21 August	East	61.0
22 August	East	30.5
23 August - 18 September	East	61.0
19-22 September	East	30.5
16 August - 22 September	West	30.5

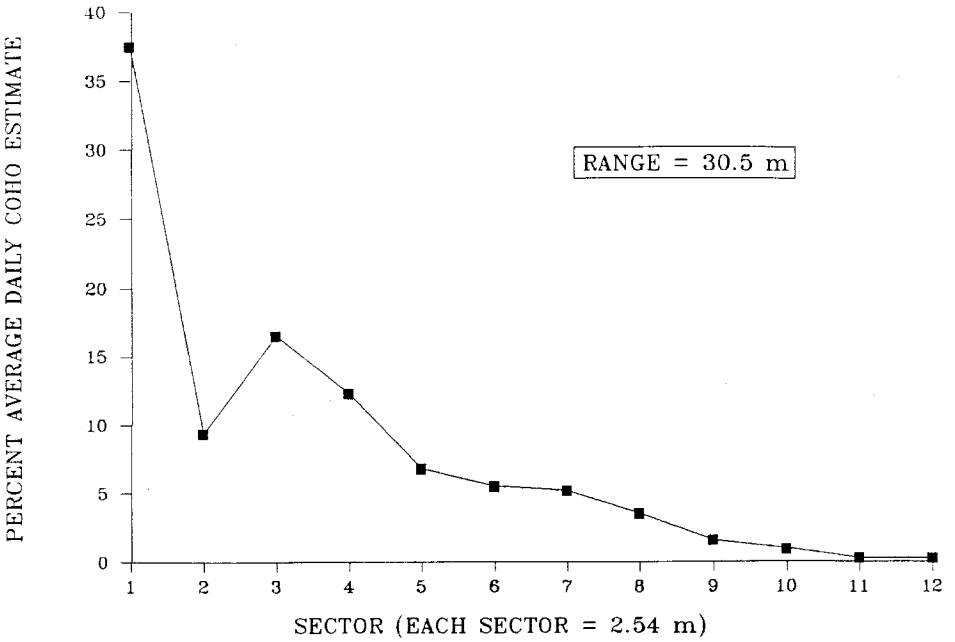

Figure 8.-Percentage of average daily coho salmon estimates by sector, for east bank, Togiak River, Alaska, 12-20 August 1987.

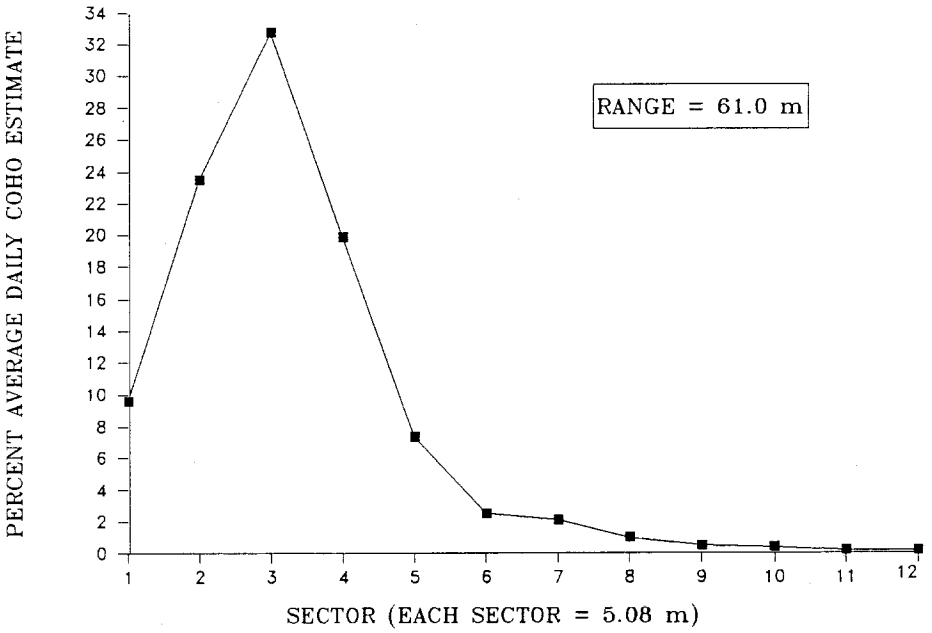

Figure 9.-Percentage of average daily coho salmon estimates by sector, for east bank, Togiak River, Alaska, 23 August-18 September 1987.

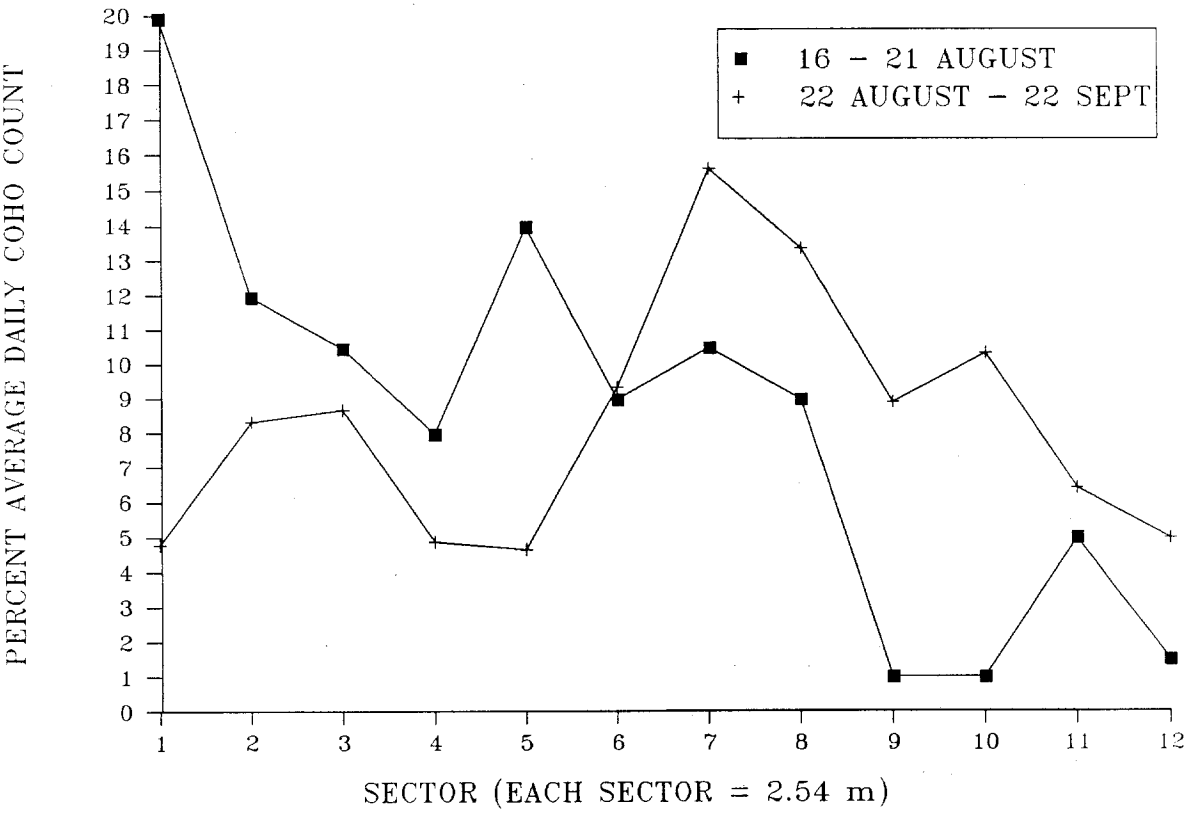

Figure 10.-Percentage of daily average coho salmon estimates by sector, for west bank, Togiak River, Alaska, 16-21 August and 22 August-22 September 1987.

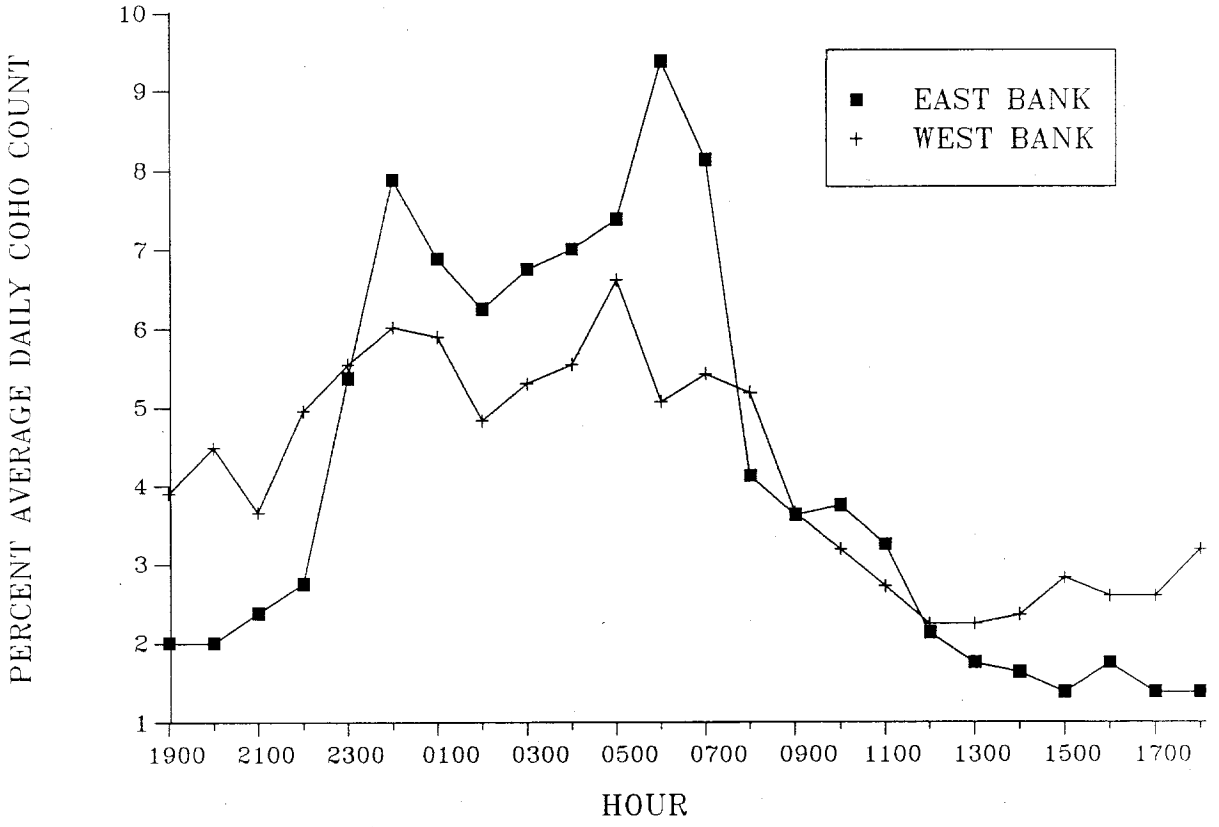

Figure 11.-East bank and west bank average coho salmon estimates by hour, as a percent of the average east and west bank daily coho salmon estimates, Togiak River, Alaska, 1987.

Table 4.-Mean length and standard error (SE) for coho salmon, Togiak River, Alaska, 1987.

Group	N	Mean Mid-Eye To Fork Length (mm)	SE
Males	172	590	3.59
Females	95	588	3.90
Age 3_2	40	576	7.14
Age 4_3	114	595	4.34
Total[a]	268	590	2.71

[a]Total includes unsexed and unaged fish

determined for 267 coho salmon with a male to female ratio of 1.8:1. This high ratio of males may be due to the males, with more developed kypes, being more susceptible to entanglement in the gill net. Mid-eye to fork length ranged from 429 to 690 mm (Figure 12).

Conclusions

Based on 1987 field activities, side-scan sonar enumeration of salmon escapements into Togiak River appears to be feasible. Successful enumeration of the five salmon species that migrate up Togiak River would provide for more timely and precise management decisions, particularly for sockeye salmon. In 1987, sonar sites with potential for enumerating salmon escapements were found and alternative sites were tested. However, determination of the feasibility of using side-scan sonar to estimate salmon escapements into Togiak River will require several more years of study.

The 1988 operational period (mid-June-September) will cover the migrations of the five salmon species which spawn in Togiak River. These sites will not account for 100 percent of the salmon escapements, as they are at Rkm 30 and above two Togiak River tributaries (Pungokepuk Creek and Gechiak Creek). However, no downstream sites were identified. Comparisons between sonar counts and Department aerial surveys of the lower river will be needed to estimate the proportions of the escapements missed by the sonar.

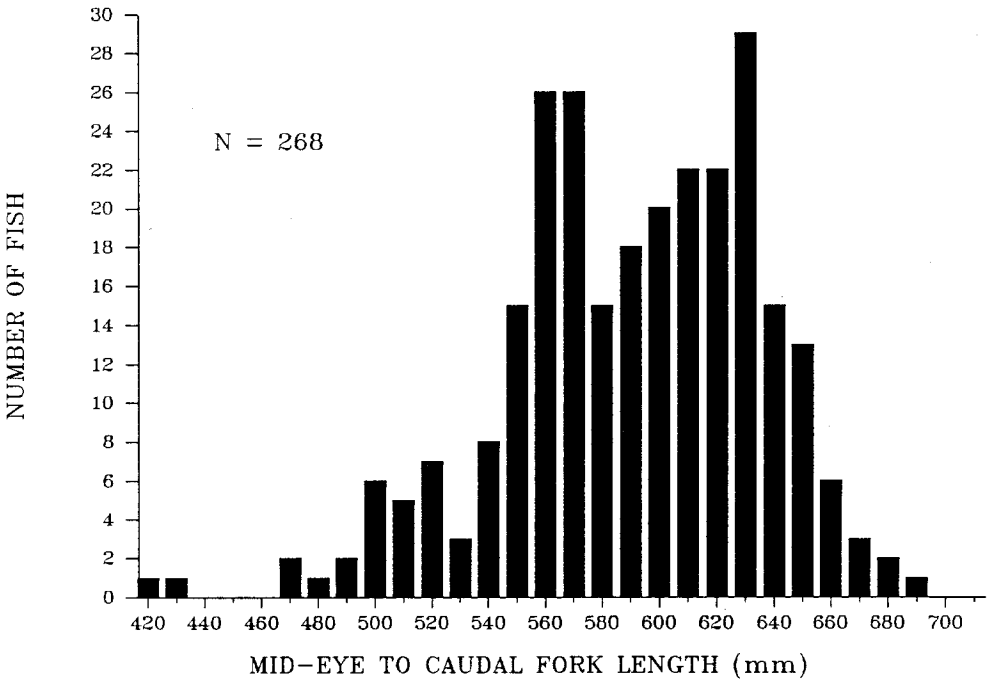

Figure 12.-Length frequency distribution of coho salmon, Togiak River, Alaska, 1987.

During low flow periods, depth and water velocities along the east bank apparently induce fish milling behavior and low swimming speeds. Moving the sonar sites 300 m downstream should allow us to overcome this problem in the future. Platforms will be erected at the alternative sites during 1988 to allow rapid deployment of sonar equipment during low water conditions.

The standard ping adjustment on Bendix salmon counters are not adequate to adjust for the swimming speeds of Togiak River salmon, and the equipment will be modified to double the ping rate adjustment range prior to the 1988 field season.

Data indicate that there may have been counting gaps on the west bank (sectors 4, 5, 9 and 10). Counting towers will be used during 1988 to validate the efficiency of the counters, and adjustment of counting ranges and transducer aiming will be done to eliminate potential counting gaps.

Gill nets of various mesh sizes, beach seines and visual observations will be used more intensively in 1988 to provide better estimates of species composition (including non-salmon species) and to provide age, length and sex data. Scale sampling will be increased so that a minimum of four scales per fish are collected.

The 1988 field season will allow us to refine fish capture techniques and to operate the sonar during the migrations of the five Pacific salmon species which spawn in the Togiak River drainage. Sockeye salmon sonar escapement estimates will be compared with Department tower and aerial survey counts to

provide a further check of the validity of sonar escapement estimates.

ACKNOWLEDGEMENTS

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Appendix A.-Visual counts of salmon passing the east and west bank sonar sites, Togiak River, Alaska, 1987.

	Visual Counts - East Bank / West Bank			
	Chum	Dark Sockeye[a]	Bright Salmon[b]	Daily Total
16 August	47 / --[c]	0 / --	10 / --	57
17 August	129 / 51	0 / 5	38 / 0	223
18 August	135 / 14	0 / 2	52 / 0	203
19 August	16 / 10	0 / 1	10 / 2	39
20 August	22 / 1	0 / 1	12 / 0	36
21 August	6 / --	0 / --	8 / --	14
22 August	25 / 5	0 / 1	18 / 4	53
23 August	-- / 2	-- / 1	-- / 6	9
24 August	9 / 3	0 / 1	2 / 1	16
Total	389 / 86	0 / 12	150 / 13	650

[a]Sockeye salmon with spawning coloration.

[b]Fresh salmon with silver coloration.

[c]No data.

Appendix B.-Beach seine and gill net catches of salmon, Togiak River, Alaska, 1987.

Date	Coho	Sockeye	Chum	Chinook	Pink	Total
12 August	0	1	1	0	0	2
13 August	1	3	4	1	1	10
14 August	0	6	12	1	0	19
15 August	2	0	10	0	0	12
17 August	1	3	12	0	0	16
18 August	4	5	16	1	0	26
19 August	5	1	10	0	0	16
20 August	3	4	7	1	0	15
21 August	2	0	0	0	1	3
24 August	4	1	0	0	0	5
25 August	4	0	2	0	0	6
26 August	13	2	8	0	0	23
27 August	24	1	1	0	0	26
28 August	12	7	2	0	0	21
29 August	12	1	1	0	0	14
31 August	34	1	4	0	1	40
1 September	13	1	0	0	1	15
2 September	32	2	2	0	0	36
3 September	30	0	1	0	0	31
4 September	42	0	0	0	0	42
8 September	13	1	0	0	0	14
9 September	6	1	0	0	0	7
10 September	2	0	0	0	0	2
13 September	20	0	0	0	0	20
15 September	1	0	0	0	0	1
17 September	1	0	0	0	0	1
21 September	1	0	0	0	0	1
Total	282	41	93	4	4	424

Appendix C.-Total adjusted side-scan sonar counts, Togiak River, Alaska, 1987.

Date	Total Adjusted Daily Sonar Counts				
	East Bank	West Bank	Banks Combined	Cumulative	Percent Cumulative
12 August	6,638	--	6,638	6,638	4.83
13 August	4,734	--	4,734	11,372	8.27
14 August	5,235	--	5,235	16,607	12.08
15 August	4,557	--	4,557	21,164	15.39
16 August	5,077	6,126	11,203	32,367	23.54
17 August	4,369	2,699	7,068	49,435	28.68
18 August	3,648	4,366	8,014	47,449	34.51
19 August	3,982	3,068	7,050	54,499	39.64
20 August	3,782	1,841	5,623	60,122	43.73
21 August	2,165	1,447	3,612	63,734	46.35
22 August	2,391	1,752	4,143	67,877	49.37
23 August	2,258	587	2,845	70,722	51.44
24 August	2,716	727	3,443	74,165	53.94
25 August	1,959	646	2,605	76,770	55.83
26 August	2,049	960	3,009	79,779	58.02
27 August	2,054	1,210	3,264	83,043	60.40
28 August	2,059	1,289	3,348	86,391	62.83
29 August	1,869	1,274	3,143	89,534	65.12
30 August	1,517	2,286	3,804	93,337	67.88
31 August	1,303	2,301	3,604	96,941	70.50
1 September	1,301	906	2,261	99,202	72.15
2 September	1,412	876	2,288	101,490	73.81
3 September	2,604	1,028	3,632	105,122	76.45
4 September	2,878	1,311	4,189	109,311	79.50
5 September	1,216	997	2,258	111,569	81.14
6 September	1,046	989	2,035	113,604	82.62
7 September	1,805	908	2,713	116,317	84.60
8 September	792	886	1,678	117,995	85.82
9 September	829	806	1,635	119,630	87.01
10 September	796	1,027	1,823	121,453	88.33
11 September	330	1,062	1,392	122,845	89.34
12 September	471	842	1,313	124,158	90.30
13 September	563	1,574	2,137	126,295	91.85
14 September	738	1,054	1,792	128,087	93.16
15 September	577	580	1,157	129,244	94.00
16 September	494	633	1,127	130,371	94.82
17 September	538	592	1,130	131,501	95.64
18 September	497	595	1,092	132,593	96.43
19 September	719	636	1,355	133,948	97.42
20 September	834	583	1,417	135,365	98.45
21 September	692	579	1,271	136,636	99.37
22 September	344	517	861	137,497	100.00
Total	85,883	51,614	137,497		

Appendix D.-Estimated coho salmon daily and moving average (based on moving average species composition estimates) side-scan sonar counts. Banks combined and cumulative values are based on moving average counts, Togiak River, Alaska, 1987.

	Estimated Daily Coho Salmon Counts						
	East Bank		West Bank				
Date	Daily Count	Moving Average	Daily Count	Moving Average	Banks Combined	Cumulative	Percent Cumulative
12 August	593	593	--	--	593	593	0.87
13 August	423	423	--	--	423	1,016	1.48
14 August	467	479	--	--	479	1,495	2.18
15 August	407	417	--	--	417	1,912	2.79
16 August	509	509	614	660	1,169	3,081	4.50
17 August	392	505	242	330	835	3,915	5.72
18 August	485	519	581	621	1,141	5,056	7.39
19 August	659	735	508	566	1,301	6,357	9.29
20 August	844	906	411	441	1,347	7,704	11.26
21 August	674	635	450	424	1,059	8,763	12.81
22 August	873	768	640	562	1,330	10,093	14.75
23 August	905	905	235	235	1,140	11,234	16.42
24 August	828	1,311	222	351	1,661	12,895	18.84
25 August	1,218	1,103	402	364	1,467	14,362	20.99
26 August	1,475	1,306	691	612	1,918	16,281	23.79
27 August	1,579	1,517	930	894	2,410	18,691	27.32
28 August	1,590	1,606	996	1,005	2,611	21,302	31.13
29 August	1,512	1,499	1,031	1,022	2,520	23,822	34.81
30 August	1,257	1,257	1,895	1,895	3,152	26,974	39.42
31 August	1,082	1,122	1,911	1,981	3,102	30,076	43.95
1 September	1,175	1,157	867	854	2,010	32,087	46.89
2 September	1,316	1,289	817	799	2,088	34,175	49.94
3 September	2,477	2,439	978	963	3,402	37,577	54.92
4 September	2,723	2,724	1,240	1,241	3,965	41,542	60.71
5 September	1,200	1,199	949	948	2,146	43,688	63.85
6 September	995	995	941	941	1,936	45,624	66.67
7 September	1,720	1,720	865	865	2,585	48,209	70.45
8 September	755	755	845	845	1,600	49,809	72.79
9 September	791	791	769	769	1,560	51,368	75.07
10 September	760	760	981	980	1,740	53,108	77.61
11 September	315	315	1,014	1,014	1,329	54,437	79.55
12 September	450	450	804	804	1,254	55,691	81.39
13 September	538	538	1,503	1,503	2,040	57,731	84.37
14 September	705	705	1,006	1,006	1,711	59,442	86.87
15 September	551	551	554	554	1,105	60,547	88.48
16 September	472	472	604	604	1,076	61,623	90.06
17 September	514	514	565	565	1,078	62,702	91.63
18 September	475	475	568	568	1,042	63,744	93.15
19 September	687	687	607	607	1,294	65,037	95.05
20 September	796	796	558	558	1,355	66,392	97.02
21 September	661	661	553	553	1,214	67,606	98.80
22 September	328	328	494	494	822	68,428	100.00
Total	38,176	38,432	29,839	29,996	68,428		